

MINISTRY OF EDUCATION, SINGAPORE  
in collaboration with  
CAMBRIDGE ASSESSMENT INTERNATIONAL EDUCATION  
General Certificate of Education Ordinary Level

CANDIDATE  
NAME

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CENTRE  
NUMBER

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INDEX  
NUMBER

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Paper 3 Chemistry

October/November 2020

1 hour 15 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

**READ THESE INSTRUCTIONS FIRST**

Write your Centre number, index number and name on all the work you hand in.

You may use an HB pencil for any diagrams, graphs, tables or rough working.

Write in dark blue or black pen.

Do not use staples, paper clips, glue or correction fluid.

The use of an approved scientific calculator is expected, where appropriate.

You may lose marks if you do not show your working or if you do not use appropriate units.

**DO NOT WRITE ON ANY BARCODES.**

**Section A**

Answer **all** questions.

Write your answers in the spaces provided on the question paper.

**Section B**

Answer any **two** questions.

Write your answers in the spaces provided on the question paper.

A copy of the Data Sheet is printed on page 15.

A copy of the Periodic Table is printed on page 16.

The number of marks is given in brackets [ ] at the end of each question or part question.

## Section A

Answer **all** the questions in the spaces provided.

- 1 When complete, Table 1.1 describes five processes and their names.

Complete the table.

**Table 1.1**

description of process	name of process
separating a precipitate from a solution	<i>filtering</i>
cooling a vapour into a liquid	
mixing equal amounts of strong acid and strong alkali	
changing long-chain hydrocarbons into short-chain hydrocarbons	
joining together thousands of small, identical molecules to form huge molecules	

[4]

2 (a) Name an alloy and list two of its constituents.

alloy .....

constituent 1 .....

constituent 2 .....

[2]

(b) A pure metal has different physical properties compared to its alloys.

Fig. 2.1 represents the atoms in a pure metal.

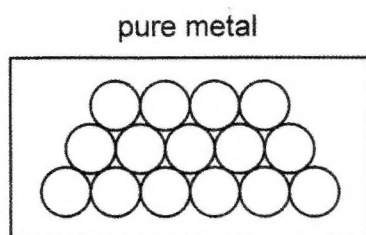


Fig. 2.1

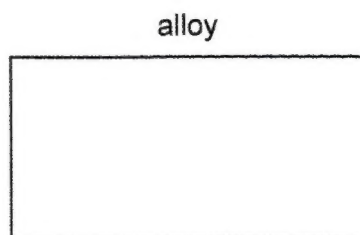


Fig. 2.2

(i) Complete Fig. 2.2, to show the arrangement of atoms in an alloy.

[1]

(ii) Describe **one** general property of metals.

.....

..... [1]

- 3 Two students need help to complete a project on iron. They list reasons why it is important to recycle metals such as iron.

(a) Suggest **three** reasons they should include in their list.

reason one .....

reason two .....

reason three .....

[3]

(b) The students have produced instructions for the preparation of a pure, dry sample of iron(II) sulfate crystals.

They have made several mistakes.

Read their instructions and complete Table 3.1 with **three** of their mistakes and corrections of these mistakes.

**Student-written instructions to prepare  
pure, dry iron(II) sulfate crystals.**

1. Wear safety goggles and gloves.
2. Start with iron filings.
3. Warm excess filings with concentrated sulfuric acid,  $\text{H}_2\text{SO}_4$ , to form a solution of iron(II) sulfate,  $\text{Fe}_2(\text{SO}_4)_3$ .
4. Filter the solution to remove any unreacted iron.
5. Gently heat the solution until brown crystals begin to form. Leave to stand.
6. Separate the crystals by filtering.
7. Clean the crystals by washing with large quantities of distilled water and dry them with filter paper.

**Table 3.1**

students' mistake	corrections to mistake

[6]

- 4 Fig. 4.1 describes some properties of a powdered mixture of compound **A** and a metal **B**.

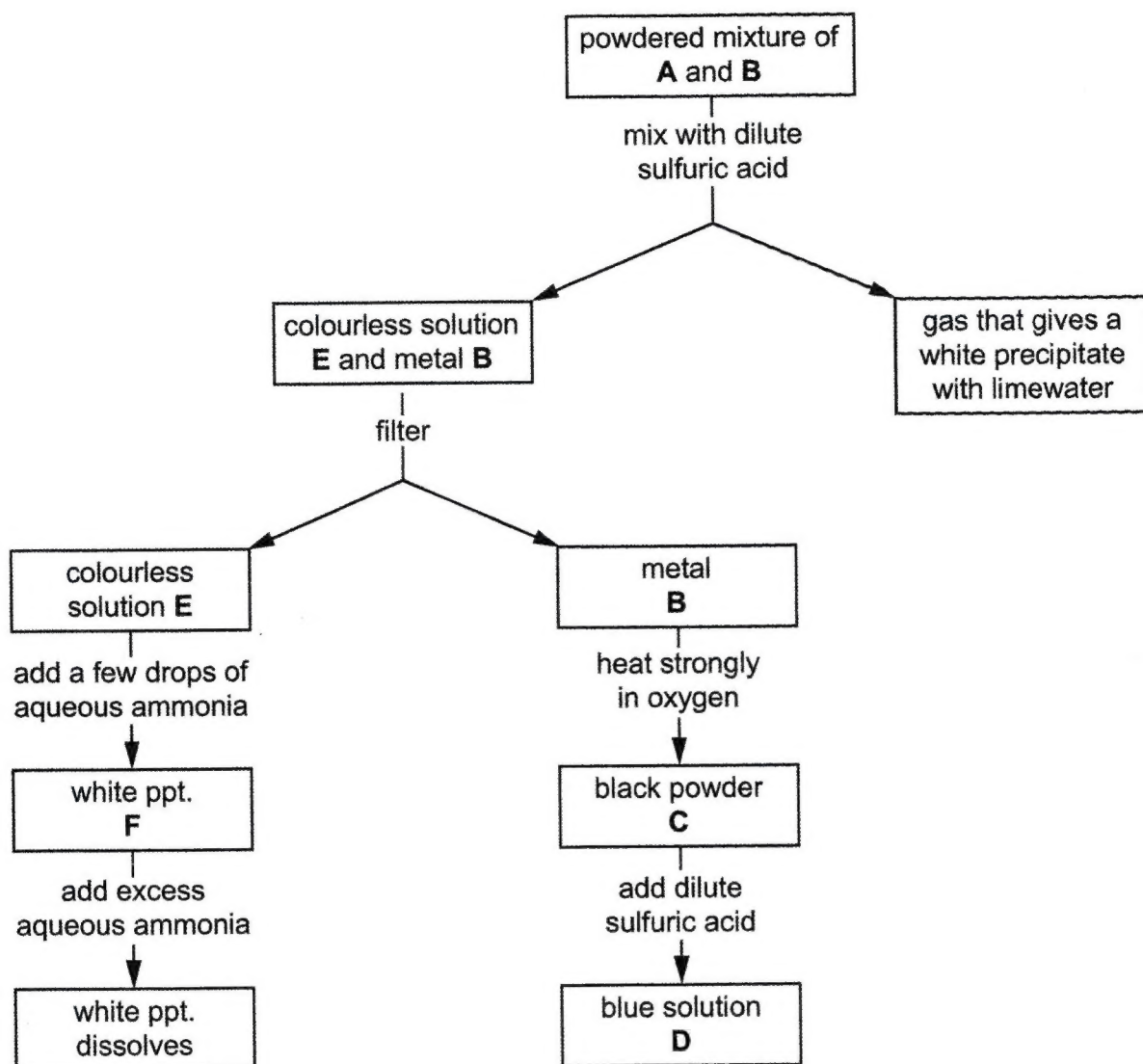


Fig. 4.1

- (a) Name **A**, **B**, **C**, **D**, **E** and **F**.

**A** .....

**B** .....

**C** .....

**D** .....

**E** .....

**F** .....

[6]

- (b) Write a balanced chemical equation, with state symbols, for any **one** of the reactions included in Fig. 4.1.

..... [3]



5 Ethanoic acid and ethanol can be distinguished by chemical tests.

- (a) Describe **two** of these chemical tests and the observations that allow you to make the distinctions.

test 1 .....

observation .....

.....

test 2 .....

observation .....

.....

[2]

- (b) The alcohols ethanol and propanol can both be used during surgery for cleansing. Both are oxidised to acids when left open to the atmosphere. The acidic products of their oxidation limit their ability to clean.

Suggest how you would determine in the laboratory which of these **two** alcohols is more quickly oxidised by air. Include all the measurements you would make.

.....

.....

.....

.....

.....

..... [4]

6 Carbon dioxide and an alcohol are produced by fermenting glucose solution.

(a) Write a balanced chemical equation for this fermentation.

[2]

(b) A glucose solution has a concentration of  $360 \text{ g/dm}^3$ .

Calculate the concentration of this solution in  $\text{mol/dm}^3$ .

[Relative atomic masses:  $A_r$ : H, 1; C, 12; O, 16]

concentration = ..... $\text{mol/dm}^3$  [1]

(c) At room temperature and pressure, 0.042 moles of carbon dioxide are needed to fill completely a balloon.

Calculate the number of moles of hydrogen required to fill completely an identical balloon, under the same conditions of temperature and pressure.

number of moles = ..... [1]

7 Tantalum (Ta), a rare metal, has five valency electrons.

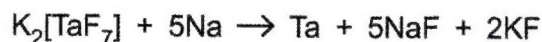
(a) Suggest the chemical formula for a chloride and for an oxide of tantalum.

chloride .....

oxide .....

[2]

(b) Tantalum capacitors are found in nearly every piece of electronic equipment, including cell phones and laptops. The metal is extracted by first converting its ore to potassium heptafluorotantalate,  $K_2[TaF_7]$ . Tantalum can then be extracted by treating this compound with sodium under extreme conditions.



(i) This reaction is exothermic. Define the term *exothermic*.

..... [1]

(ii) In this reaction sodium reacts to form sodium fluoride.

State whether the sodium has been oxidised or reduced or neither of these, and explain your answer.

.....

explanation .....

.....

[2]

(iii) Carbon and zinc can be used to separate tantalum from tantalum oxide.

Suggest what this tells you about the relative chemical reactivity of tantalum.

..... [1]



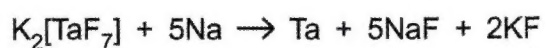
(c) Calculate:

- (i) the mass of one mole of potassium heptafluorotantalate,  $K_2[TaF_7]$

[Relative atomic masses:  $A_r$ : F, 19; K, 39; Ta, 181]

mass = ..... g [1]

- (ii) the mass of sodium needed to extract 2000g of tantalum from potassium heptafluorotantalate.



[Relative atomic masses:  $A_r$ : F, 19; Na, 23; K, 39; Ta, 181]

mass = ..... g [2]

## Section B

Answer any **two** questions in this section.

Write your answers in the spaces provided.

**8** Ethane has a relative molecular mass of 30.

(a) Define the term *relative molecular mass*.

.....  
..... [2]

(b) Ethane and calcium chloride have quite different electronic structures.

(i) State the electronic structures of carbon and calcium.

[Proton (atomic) number: C, 6; Ca, 20]

carbon .....  
calcium ..... [2]

(ii) Draw 'dot and cross' diagrams to show the arrangement of the outer shell electrons in calcium chloride and ethane.

[Proton (atomic) number: H, 1; C, 6; Cl, 17; Ca, 20]

calcium chloride

[2]

ethane

[2]

(c) Molten calcium chloride conducts electricity, but solid calcium chloride and ethane do not.

You may use your diagrams in (b)(ii) to help explain this difference.

.....

.....

.....

.....

[2]

- 9 (a) Alkanes and alkenes are two different homologous series.

Write the general formula for each series.

- (i) alkanes

..... [1]

- (ii) alkenes

..... [1]

- (b) Members of the same homologous series have the same general formula.

State **three** other general characteristics of members of the same homologous series.

.....  
.....  
.....  
.....  
..... [3]

- (c) You are to distinguish between two gaseous compounds. One is propane, an alkane, and the other is propene, an alkene.

Describe the method you could use and the observations you would expect to make.

- (i) method

.....  
.....

observations

.....  
..... [3]

- (ii) Write a balanced chemical equation for any reaction that takes place in your method.

..... [2]

- 10 (a)** The halogens, fluorine, chlorine, bromine and iodine, are in Group VII of the Periodic Table, as shown on page 16.

Use the Periodic Table to:

- (i)** identify and name another halogen.

name ..... [1]

- (ii)** help you decide how fluorine compares in reactivity with the other halogens.

.....  
..... [1]

- (b)** The melting point of the elements in Group VII gradually increases down the group.

Use your knowledge of the kinetic particle theory to help you explain this increase.

.....  
.....  
.....  
.....  
..... [3]

- (c)** Chlorine displaces a halogen from each of the halide ions below it in Group VII.

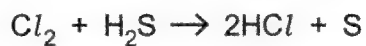
- (i)** Write the balanced ionic equation for any one of these displacements.

..... [2]

- (ii)** Describe the observations for the displacement reaction in **(c)(i)**.

.....  
..... [1]

- (d) Chlorine will displace sulfur from hydrogen sulfide and form gaseous hydrogen chloride.



Use the balanced chemical equation for this displacement to calculate the volume of chlorine needed to liberate 3000 dm<sup>3</sup> of gaseous hydrogen chloride at room temperature and pressure.

volume of chlorine = ..... dm<sup>3</sup> [2]

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32. (A)

Since XO is an insoluble solid, the universal indicator remains unchanged.

An amphoteric oxide can react with both acids and bases, thus can react with both hydrochloric acid (an acid) and sodium hydroxide (a base).

**EXAM TIP:**

An amphoteric oxide reacts with both acids and alkalis.

33. (A)

Down Group I, the melting point of elements decreases, thus R is positioned higher in the Periodic Table than T. Therefore, R has less electron shells than T.

**EXAM TIP:**

Down Group I, the melting point of elements decreases and reactivity increases.

34. (A)

Since Y can react with P, Q and S, it is the most reactive metal.

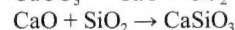
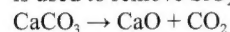
Since X cannot react with any of the metal oxides, it is the least reactive metal.

**EXAM TIP:**

A more reactive metal displaces a less reactive metal from its oxide.

35. (D)

Limestone decomposes to give calcium oxide, which is used to remove  $\text{SiO}_2$  impurities.



**EXAM TIP:**

In the extraction of iron from its ore, limestone is added to remove impurities such as  $\text{SiO}_2$ .

36. (D)

Oxygen reacts with copper to form copper oxide. Since air consists of approximately 20% oxygen, the volume of air decreases from  $50 \text{ cm}^3$  to  $40 \text{ cm}^3$ .

**EXAM TIP:**

The volume composition of gases present in dry air is approximately 78% nitrogen, 21% oxygen and the remainder (approximately 1%) comprises noble gases (with argon as the main constituent) and carbon dioxide.

38. (D)

Petrol (gasoline) has the lowest boiling point, followed by diesel, and then bitumen.

**EXAM TIP:**

Petroleum is separated into useful fractions by fractional distillation.

39. (D)

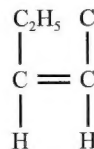
Methane undergoes substitution reaction with chlorine gas in ultraviolet light.

**EXAM TIP:**

Alkanes undergo substitution reactions only.

40. (B)

The chemical structure of the monomer is:



**EXAM TIP:**

Identify the repeat unit from the given part of the structure.

October/November 2020

Paper 3

Section A

1.

description of process	name of process
separating a precipitate from a solution	<i>filtering</i>
cooling a vapour into a liquid	<b>condensation</b>
mixing equal amounts of strong acid and strong alkali	<b>neutralisation</b>
changing long-chain hydrocarbons into short-chain hydrocarbons	<b>cracking</b>
joining together thousands of small, identical molecules to form huge molecules	<b>polymerisation</b>

**EXAM TIP:**

- The process where a substance undergoes a change from gaseous state to liquid state is called condensation.
- Neutralisation is a reaction in which an acid and a base react to form a salt and water.
- Large hydrocarbons can be broken down into smaller molecules through cracking.
- Polymerisation is the process of joining together a large number of small, identical molecules (monomers) to form huge molecules.

2. (a) alloy: steel

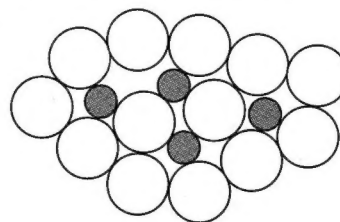
constituent 1: iron

constituent 2: carbon

**EXAM TIP:**

Recall examples of alloys and their constituents.

(b) (i)





(ii) Any one of the following:

- Metals have high melting and boiling points.
- Metals are good conductors of electricity in both solid and molten states.

**EXAM TIP:**

Metals generally exist as solids at room temperature (with the exception of mercury), have high melting and boiling points (with the exception of mercury), are malleable and are good conductors of heat and electricity.

3. (a) reason one: Metal ores are a finite resource, so recycling metals will help to conserve natural resources.

reason two: Pollution arising from disposing metals in landfills would be reduced.

reason three: Recycling metals conserves energy.

**EXAM TIP:**

Metal ores are a finite resource and hence there is a need to recycle metals.

(b) Any three of the following:

students' mistake	corrections to mistake
The chemical formula of iron(II) sulfate was written as $\text{Fe}_2(\text{SO}_4)_3$ .	The chemical formula of iron(II) sulfate should be $\text{FeSO}_4$ .
It was written that concentrated sulfuric acid is to be used.	Dilute sulfuric acid should be used instead.
It was written that the solution should be heated until brown crystals begin to form.	The solution should be heated until it is saturated and left to cool for crystals to form.
It was written that the crystals are to be washed with large quantities of distilled water.	Crystals should be washed with small quantities of distilled water.

**EXAM TIP:**

A pure, dry sample of soluble salt can be prepared through crystallisation.

4. (a) A: zinc carbonate  
B: copper  
C: copper(II) oxide  
D: copper(II) sulfate  
E: zinc sulfate  
F: zinc hydroxide

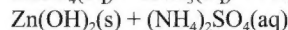
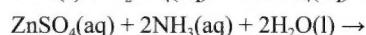
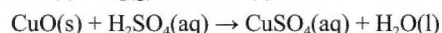
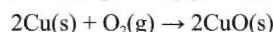
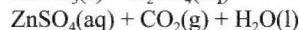
**EXAM TIP:**

Acids react with carbonates to form carbon dioxide gas, which gives a white precipitate with limewater.

Aqueous ammonia is used to identify the cation.

Metal is heated strongly in oxygen to form metal oxide, which reacts with sulfuric acid to form sulfate solution.

(b) Any one of the following:



5. (a) test 1: Add acidified potassium manganate(VII) into separate test-tubes containing ethanoic acid and ethanol respectively.

observation: Ethanol will turn purple potassium manganate(VII) colourless. No change is observed in the test-tube containing ethanoic acid.

test 2: Add sodium carbonate solution (or any other carbonate solution) into separate test-tubes containing ethanoic acid and ethanol respectively.

observation: Effervescence is observed in the test-tube containing ethanoic acid. No change is observed in the test-tube containing ethanol.

**EXAM TIP:**

When heated with oxidising agents such as acidified potassium manganate(VII), alcohols undergo oxidation to form carboxylic acids. Ethanoic acid is a weak acid, which reacts with carbonate to form carbon dioxide gas.

(b) In each conical flask containing ethanol and propanol, add equal volume of sodium carbonate solution and connect a gas syringe to each conical flask.

The volume of carbon dioxide gas produced can be measured over time.

Plot a graph to measure the rate of reaction.

The alcohol that takes a shorter time to react with the atmosphere completely, as indicated by a steeper initial gradient of the graph, is more quickly oxidised by air.

**EXAM TIP:**

The rate of reaction can be determined by measuring the rate of gas evolved.

6. (a)  $\text{C}_6\text{H}_{12}\text{O}_6(\text{aq}) \rightarrow 2\text{C}_2\text{H}_5\text{OH}(\text{aq}) + 2\text{CO}_2(\text{g})$

**EXAM TIP:**

Fermentation occurs naturally in yeasts to produce ethanol.

(b)  $M_r$  of glucose =  $6(12) + 12(1) + 6(16)$   
= 180

Concentration ( $\text{mol/dm}^3$ ) =  $360 \div 180$   
=  $2.00 \text{ mol/dm}^3$

**EXAM TIP:**

Concentration ( $\text{mol/dm}^3$ ) =  $\frac{\text{Concentration of solution in g/dm}^3}{\text{Molar mass of reactant in g/mol}}$

(c) 0.042 mol

**EXAM TIP:**

1 mole of any gas occupies the same volume ( $24 \text{ dm}^3$ ) at r.t.p.



7. (a) chloride:  $\text{TaCl}_5$   
oxide:  $\text{Ta}_2\text{O}_5$

**EXAM TIP:**

Tantalum has five valency electrons, hence it can form ions with a charge of 5+.

- (b) (i) An exothermic reaction is a reaction that gives out heat energy to the surroundings.  
(ii) Sodium is oxidised.  
explanation: The oxidation state of sodium increased from 0 in Na to +1 in NaF.

**EXAM TIP:**

The reaction that involves an increase in oxidation state of a substance indicates an oxidation reaction.

- (iii) Tantalum is less reactive than both carbon and zinc.

**EXAM TIP:**

The more reactive element displaces the less reactive element in a reaction.

- (c) (i)

$$\begin{aligned}\text{Mass of } \text{K}_2[\text{TaF}_7] &= \text{Number of moles} \times \text{Molar mass} \\ &= 1 \times (2 \times 39 + 181 + 7 \times 19) \\ &= 392 \text{ g}\end{aligned}$$

- (ii) Number of moles of tantalum

$$= \frac{2000}{181}$$

$$= 11.05 \text{ mol}$$

5 moles of Na are required to extract 1 mole of Ta.

$\therefore$  Number of moles of Na required

$$= 11.05 \times 5$$

$$= 55.25 \text{ mol}$$

$$\text{Mass of Na required} = 55.25 \times 23$$

$$= 1270.75$$

$$= 1270 \text{ g (to 3 s.f.)}$$

**EXAM TIP:**

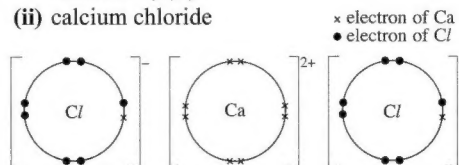
$$\text{Number of moles of substance} = \frac{\text{Mass}}{\text{Molar mass}}$$

**Section B**

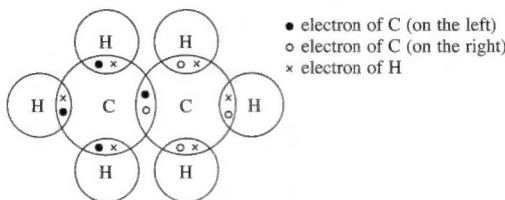
8. (a) Relative molecular mass is defined as the ratio of the average mass of a molecule to  $\frac{1}{12}$  the mass of one carbon-12 atom.

- (b) (i) carbon: 2,4  
calcium: 2,8,8,2

- (ii) calcium chloride



ethane



**EXAM TIP:**

The  $\text{Ca}^{2+}$  and  $\text{Cl}^-$  ions of calcium chloride are bonded by ionic bonds.

The C and H atoms of ethane are bonded by covalent bonds.

- (c) In molten calcium chloride, the free-moving ions can act as mobile charge carriers to conduct electricity. In solid calcium chloride, the ions are held in a lattice structure and are unable to move freely to conduct electricity. Carbon dioxide has a simple molecular structure and does not have free-moving ions or electrons to conduct electricity.

**EXAM TIP:**

A substance conducts electricity if it has mobile ions or electrons.

9. (a) (i) alkanes:  $\text{C}_n\text{H}_{2n+2}$

- (ii) alkenes:  $\text{C}_n\text{H}_{2n}$

- (b) All the members of the same homologous series share the same functional group, have the same chemical reactions, and each member of the series differs from the next by a  $-\text{CH}_2$  group.

**EXAM TIP:**

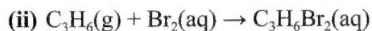
Homologous series is a group of compounds with a general formula, with similar chemical properties and show a gradual change in physical properties (such as melting point, boiling point, viscosity and flammability) as a result of an increase in the size and mass of the molecules.



- (c) (i) method: Bubble both gases into different test-tubes containing bromine solution.
- observations: For propene, the colour of the bromine solution changes from reddish-brown to colourless. For propane, there is no change in the colour of the bromine solution.

**EXAM TIP:**

The addition of bromine is used to distinguish between an alkane and an alkene.



10. (a) (i) Astatine
- (ii) Fluorine is positioned highest in Group VII of the Periodic Table, thus it is the most reactive halogen.
- (b) Down Group VII, the intermolecular forces of attraction between the molecules become stronger. More energy is required to overcome the stronger intermolecular forces of attraction between molecules, resulting in a higher melting point down Group VII.
- (c) (i)  $\text{Cl}_2(\text{g}) + 2\text{Br}^-(\text{aq}) \rightarrow 2\text{Cl}^-(\text{aq}) + \text{Br}_2(\text{aq})$
- (ii) The colourless bromide solution turns reddish brown.

**EXAM TIP:**

A more reactive halogen displaces a less reactive halogen from its halide solution.

- (d) 1 mole of  $\text{Cl}_2$  gas liberates 2 moles of  $\text{HCl}$  gas.
- Volume of chlorine gas =  $3000 \div 2$   
 $= 1500 \text{ dm}^3$

**EXAM TIP:**

Use the mole ratio provided by the balanced equation to find the volume of chlorine needed.

October/November 2019

Paper 1

Multiple Choice Questions

21. (D)

To study the rate of reaction between magnesium and dilute hydrochloric acid, the volume of hydrogen gas per unit time is measured. A conical flask is required to contain the chemicals; a stopwatch is required to measure the time intervals of the reaction; a gas syringe is required to measure the volume of hydrogen gas produced at regular time intervals.

**EXAM TIP:**

A Bunsen burner is not required for this experiment as heating of the reaction mixture is not required.

22. (C)

Since solid X forms white precipitate in aqueous sodium hydroxide, which is soluble in excess sodium hydroxide, X could contain zinc, aluminium or lead ion. When powdered aluminium is added to the test-tube and carefully heated, ammonia gas is evolved which turns damp red litmus paper blue. This indicates the presence of nitrate ion. From the information given, out of all 4 options, X can only be lead(II) nitrate.

**EXAM TIP:**

Recall the test for cation and anion. A gas that turns damp red litmus paper blue is alkaline.

23. (C)

Fluorine atom gains 1 electron to form fluoride ion to attain a noble gas electronic configuration. Thus fluoride ion has an electronic configuration of 2,8.

**EXAM TIP:**

Determine the number of electrons and electronic configuration of the element and its corresponding ion.

24. (C)

Sodium chloride ( $\text{NaCl}$ ) contains positive ions ( $\text{Na}^+$ ) and negative ions ( $\text{Cl}^-$ ), which are arranged in a giant crystal lattice. There are strong electrostatic forces of attraction between the positive and negative ions. A large amount of energy is required to overcome the strong forces of attraction, thus  $\text{NaCl}$  has a high melting point. It is also soluble in water.

**EXAM TIP:**

Ionic compounds have high melting points.

25. (A)

Based on the 'dot and cross' diagram, it can be deduced that  $\text{AB}_3$  is a covalent compound. Thus, both A and B are non-metals. Since A has 5 valence electrons, it belongs to Group V of the Periodic Table. B is hydrogen as it is a non-metal with only 1 valence electron. Only the outer shell electrons are shown in the 'dot and cross' diagram, so the molecule actually contains a total of more than eight electrons.

**EXAM TIP:**

From the 'dot and cross' diagram, determine the type of compound  $\text{AB}_3$  is and its corresponding atoms.

26. (B)

From the chemical formula, chromium sulfate contains  $\text{Cr}^{3+}$  ions and  $\text{SO}_4^{2-}$  ions.

**EXAM TIP:**

Identify the charge of the ions present based on the chemical formula.